Constraining the CO_2 Missing Sink: Terrestrial Controls on Atmospheric Carbon Composition

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Using "Top down" and "Bottom up" Modeling constrained by observations to quantify underlying mechanisms

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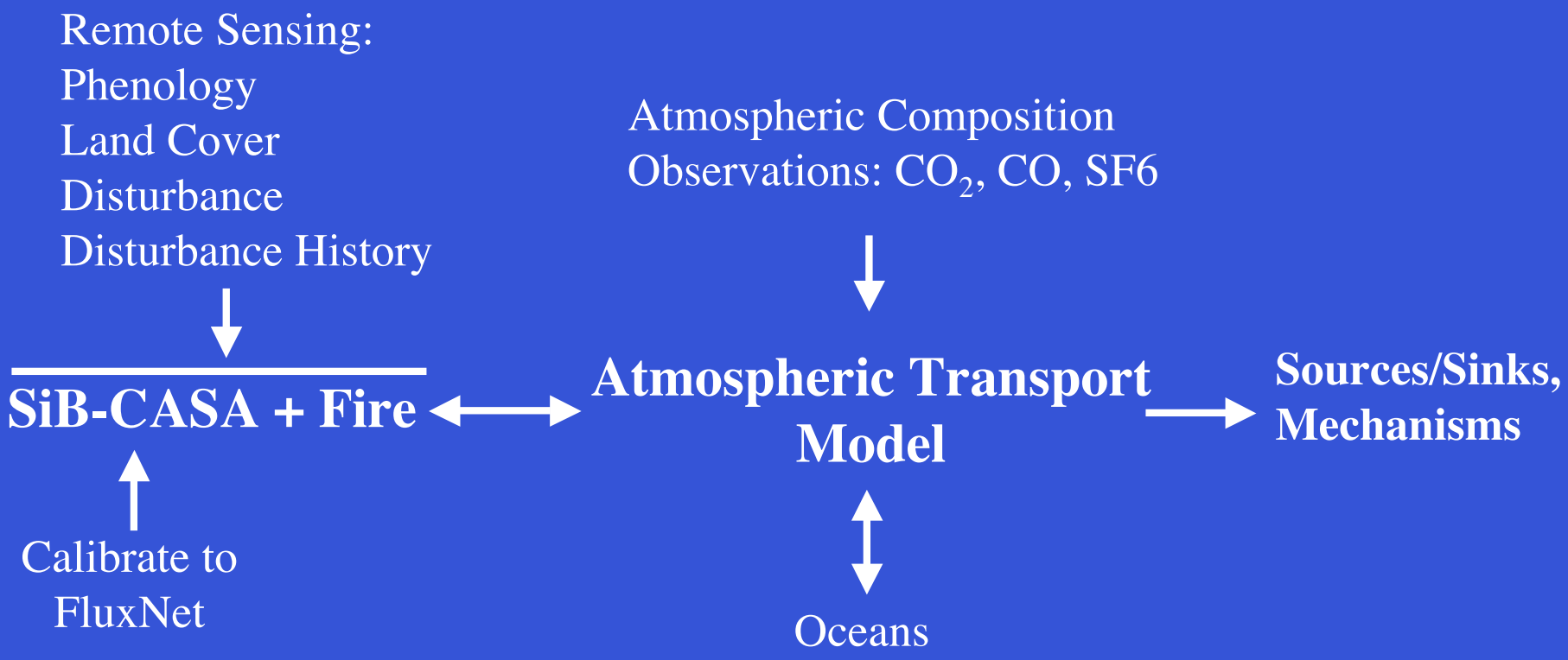
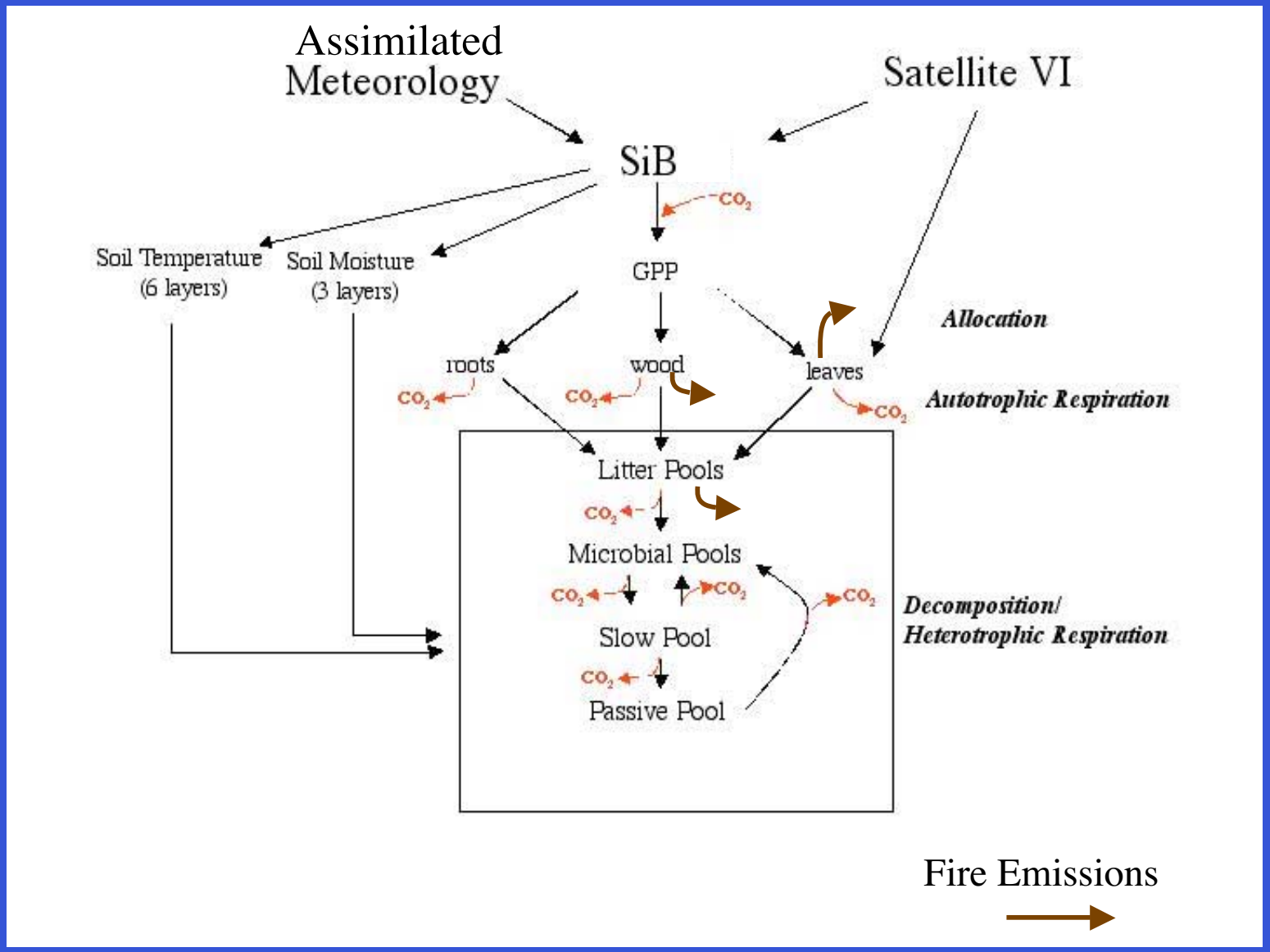
Approach

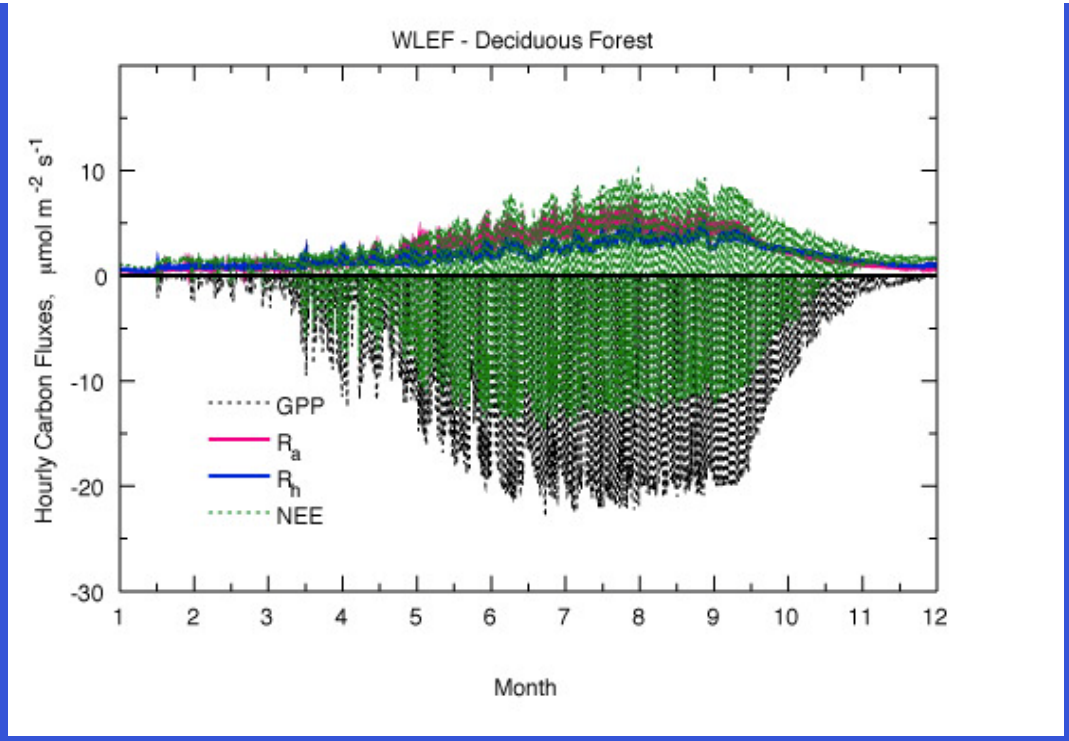


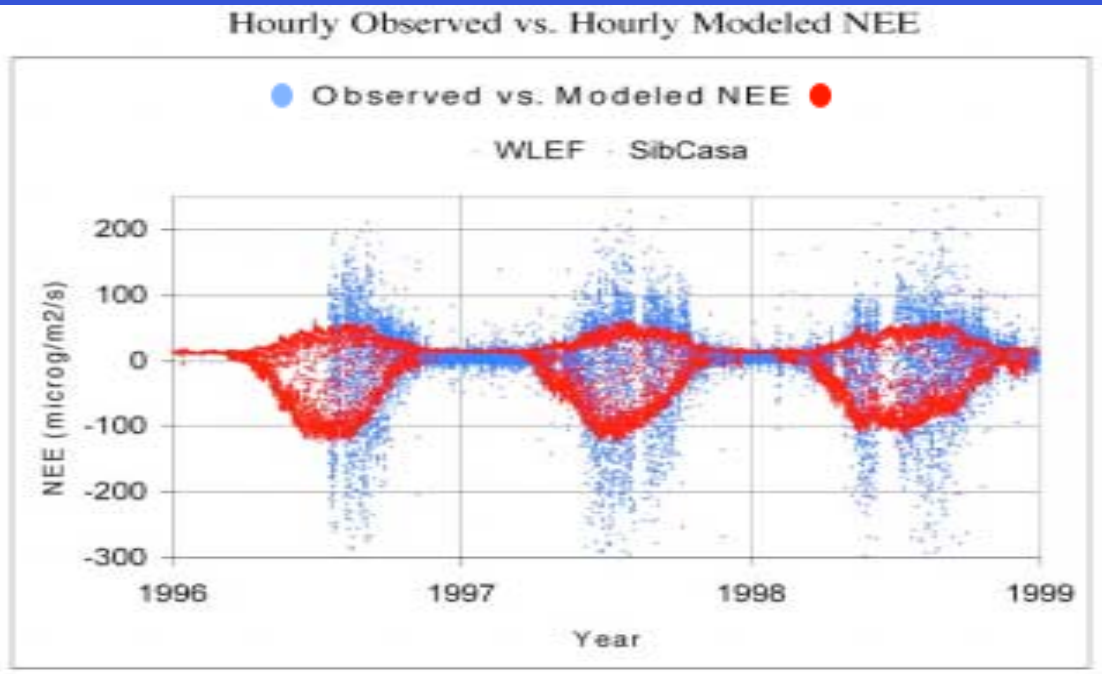
Scientific Products:

- Temporal and Spatial quantification of carbon sources and sinks
- Biogeochemical (& anthropogenic) controls on carbon fluxes
- Modeling methods and infrastructure for evaluating new CO_2, CO measurement from space

SiB - CASA


Assimilated Meteorology
Satellite VI
SiB
CO_2
Soil Temperature (6 layers)
Soil Moisture (3 layers)
GPP
Allocation
roots
wood
leaves
CO_2
Autotrophic Respiration
Litter Pools
Microbial Pools
Slow Pool
Passive Pool
Decomposition/ Heterotrophic Respiration
Fire Emissions


WLEF - Deciduous Forest
Hourly Carbon Fluxes, µmol m-2 s-1
10
0
-10
-20
-30
GPP
Ra
Rh
NEE
1
2
3
4
5
6
7
8
9
10
11
12
Month


Hourly Observed vs. Hourly Modeled NEE
Observed vs. Modeled NEE
WLEF SibCasa
NEE (microg/m2/s)
200
100
0
-100
-200
-300
1996
1997
1998
1999
Year

SiB-CASA Development Plans:

- Using data assimilation approaches optimize model parameters (e.g. pool sizes, Q10s, water stress allocation) for various vegetation types.
  Optimize using local measurements as constraints (fluxes, phenology, allometry)
  - Tropical Forest
  - Boreal Forest
  - Deciduous Broad-Leaf Forest
  - Grasslands/Crop lands

- Implement SiB-CASA globally (1° x 1.25°) with Atmospheric Transport
- Develop inverse/assimilation approaches for estimating
  - ➢ Source and Sinks
  - ➢ Uncertainties
  - ➢ Underlying mechanisms

Constraining the CO_2 Missing Sink: Atmospheric Transport Modeling

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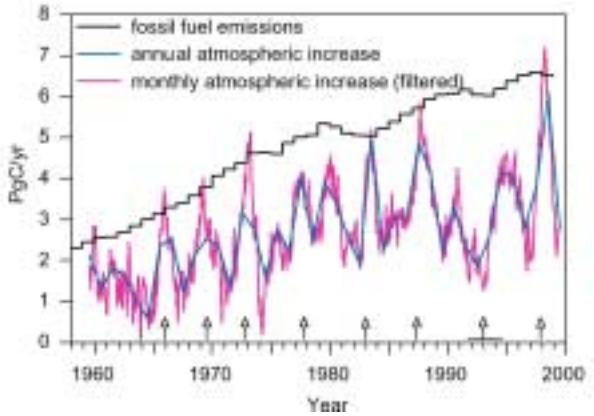
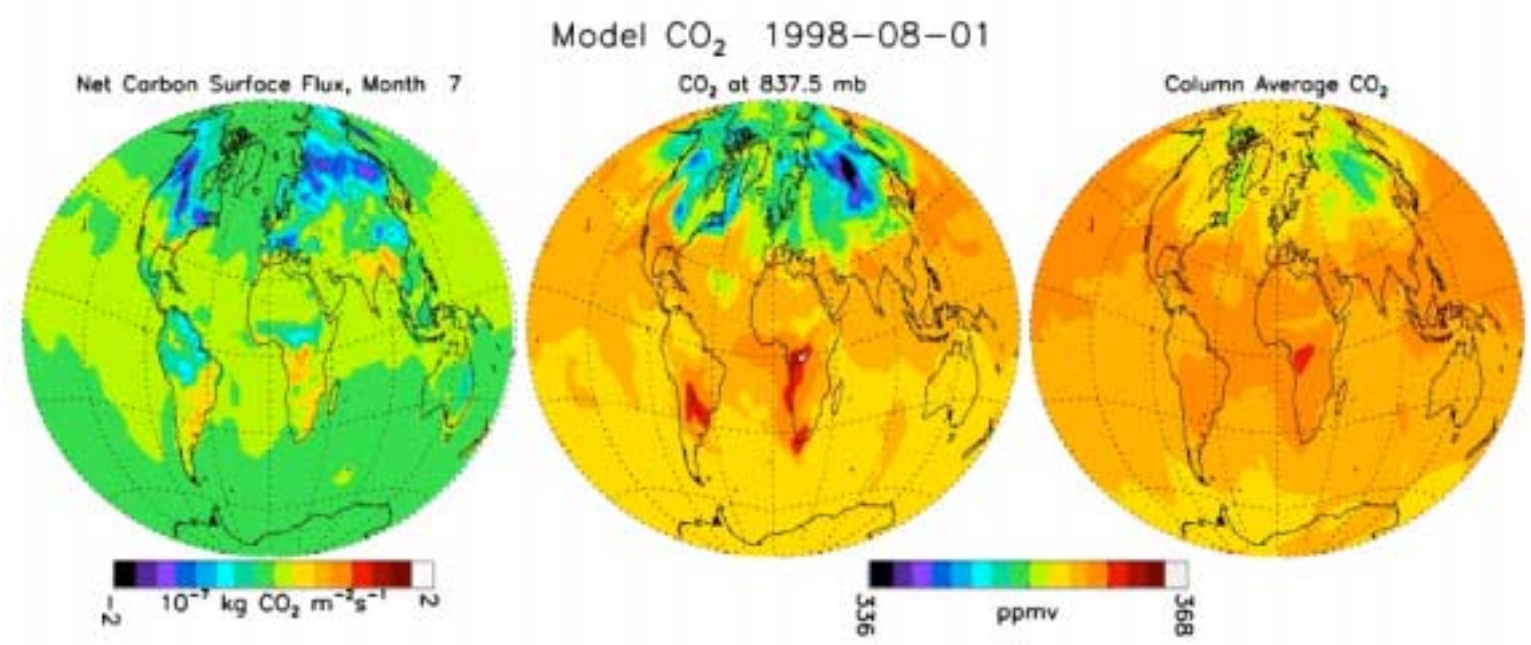
March 17, 2004



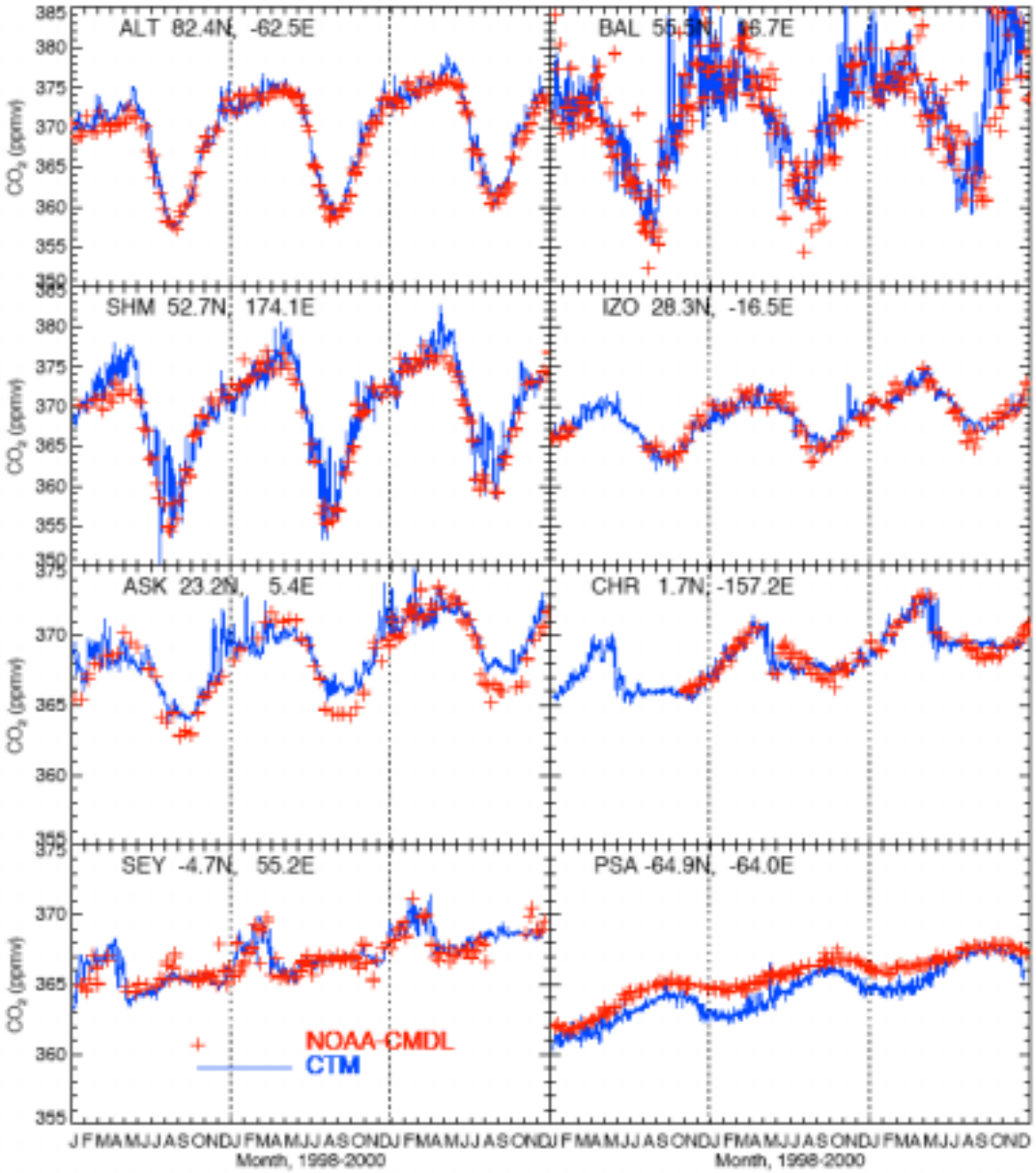
- Science Objective: Reduce uncertainty in carbon cycle processes that create the inferred NH terrestrial biosphere sink for atmospheric CO_2
- Role of Transport Model: Provide framework f observations (on synoptic to global, hourly to interannual scales)
  - Transport modeling uncertainty and improvement
  - Variability in terrestrial biosphere uptake and release
    - Constrained by satellite data
    - Linked to assimilated meteorology
  - Use of new data sources, especially satellite remote sensing
    - Impact of new and planned CO_2 data
    - Biomass burning source of CO_2

Parameterized Chemistry and Transport Model (PCTM)

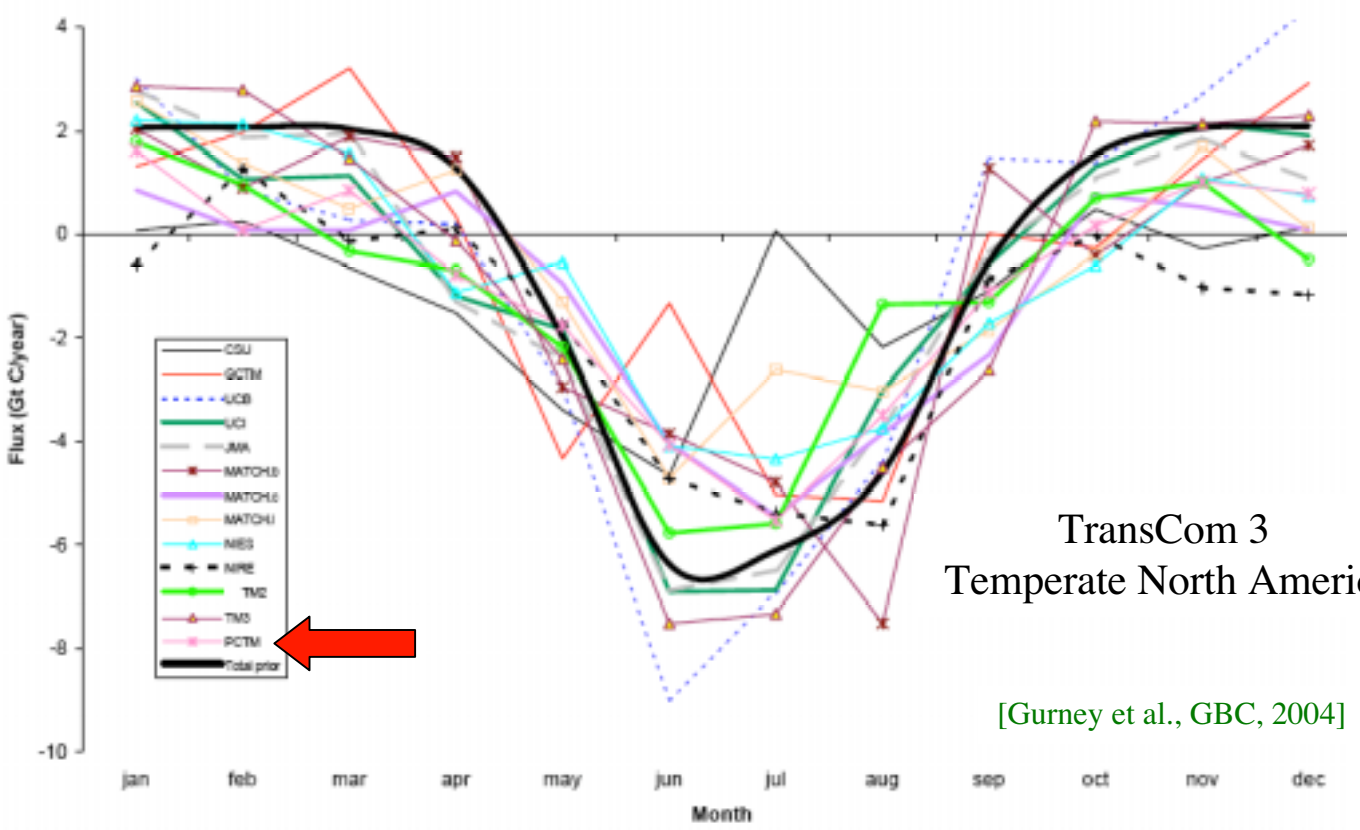
- Meteorological Data: Goddard Earth Observing System 4, Finite Volume-Data Assimilation System for 1998-2000.
- Off-line integration with state-of-the-art advection, mass conservation, convective transport, and planetary boundary layer parameterizations.
- Model grid: 2° latitude x 2.5° longitude x 25 terrain-following/pressure levels to 0.4 mbar.



Large-Scale Comparisons



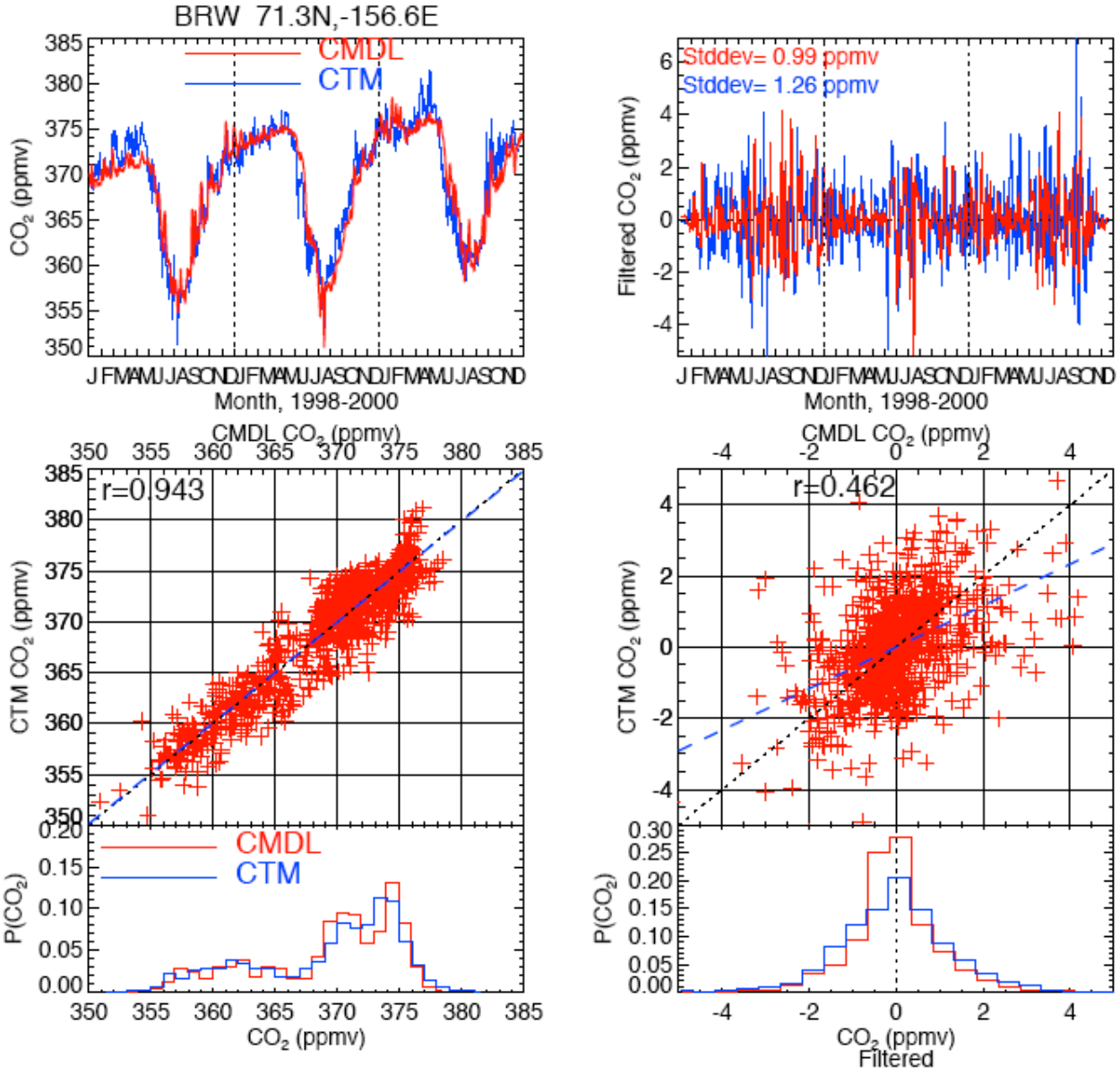
Transport Uncertainty and Inverse Calculations



- Uncertainty in transport and hence inferred fluxes is large.
- PCTM is representative of current models.

Synoptic Variations

- Daily variation in CO_2 due to transport in synoptic weather systems is simulated.
- New high spatial and temporal resolution data enable process evaluation globally.
- Need to develop analysis methods to best exploit the data.

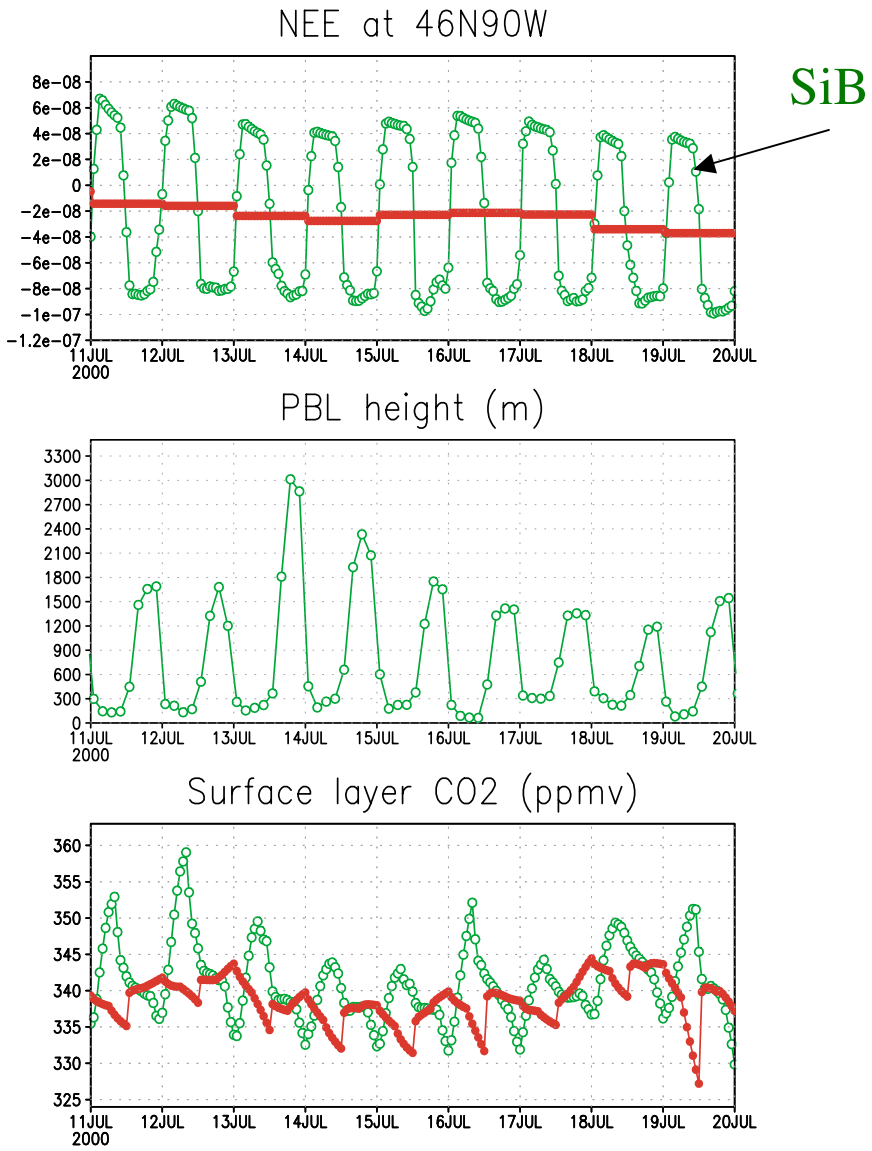


Resolving the Rectifier Effect

- Comparison to data over active vegetation requires accurate simulation of planetary boundary layer/flux interaction.

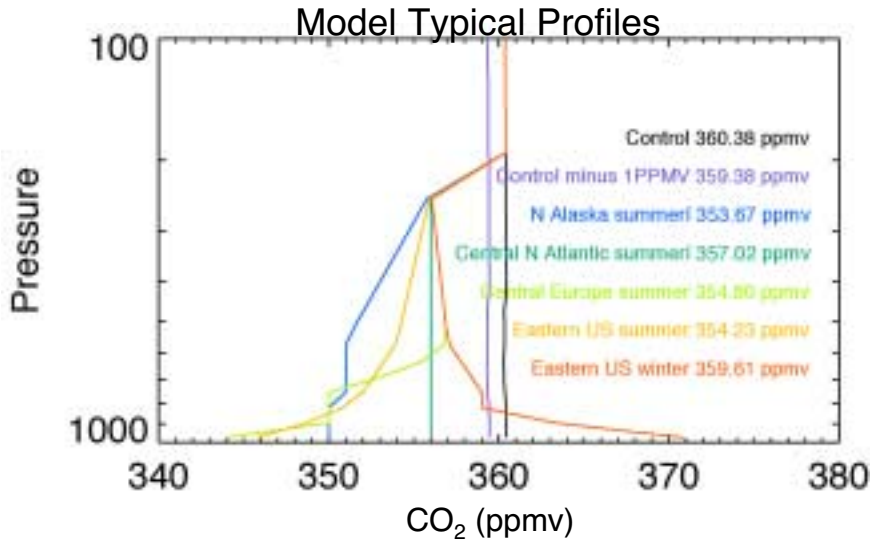
- Large scale transport is also affected.

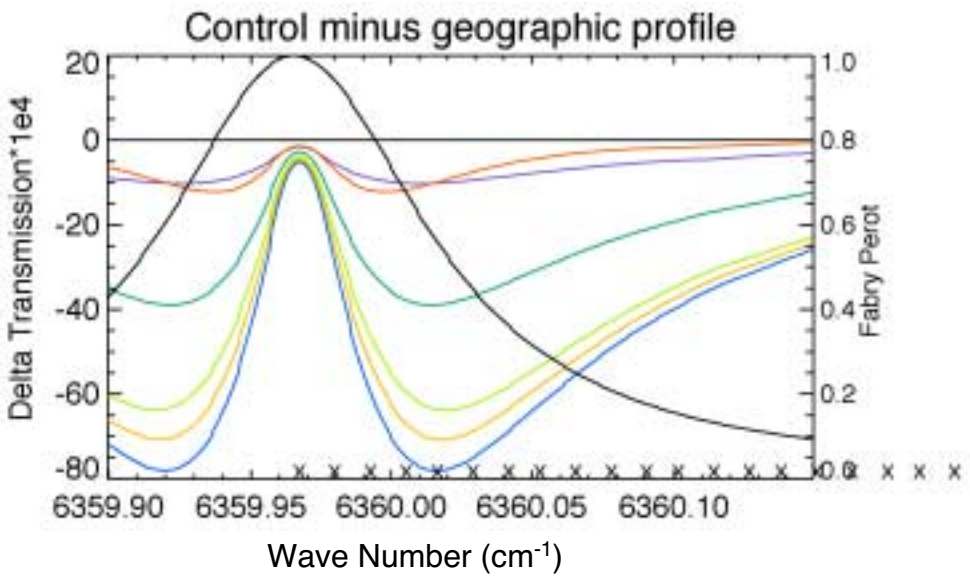
- Similar for temporally varying fossil fuel emission.

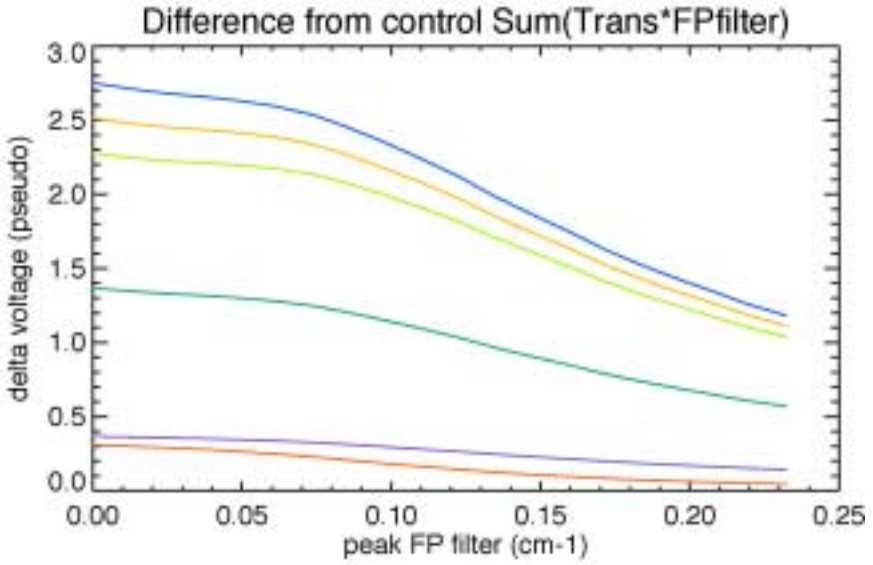


Interaction with Instrument Systems

- Model calculations can be used to guide instrument development and data reduction.
  - -Data impact studies.
  - -Observing system simulation experiments.
  - -Input to retrieval algorithms.







[C. J. Weaver, 2004]

Directions and Issues

- Medium-term plans/proposals/applications
  - Link SiB/CASA to assimilation transport
  - Explore potential of remote sensing
    - Evaluate impact of AIRS CO_2 data
    - Prepare for analysis of OCO data
    - Guide science measurement requirements
  - Contribute to NACP

- Long-term goals:
  - Multi-disciplinary satellite data assimilation system for carbon cycle processes
  - Coupled climate-carbon predictions with uncertainties

- Issues:
  - Support for carbon cycle science at NASA, GSFC, and 900 Directorate
  - Computing

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  - C. Barnet/NOAA NESDIS

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- References:

  - Mao, J., S. R. Kawa, Sensitivity studies for space-based measurement of atmospheric total column carbon dioxide by reflected sunlight, Appl. Optics, 43, 914-927, 2004.
  - Kawa, S. R., D. J. Erickson III, S. Pawson, Z. Zhu, Global CO_2 transport simulations using meteorological data from the NASA data assimilation system, J. Geophys. Res., submitted, 2004.